CLAIMS

1. A solid-state imaging device including a filter unit that selectively transmits incoming light,

the filter unit comprising two λ/4 multilayer films, and an insulation layer sandwiched between the λ/4 multilayer films,

each of the λ/4 multilayer films including a plurality of dielectric layers, and

an optical thickness of the insulation layer being different from λ/4.

2. The solid-state imaging device of Claim 1, wherein

each of the two λ/4 multilayer films includes:

a first dielectric layer made of a material having a different refractive index from a material forming the insulation layer; and

a second dielectric layer made of a material having a substantially same refractive index as the material forming the insulation layer, and

the first dielectric layer is formed so as to be in contact with a main surface of the insulation layer, and the second dielectric layer is formed so as to be in contact with a main surface of the first dielectric layer which faces away from the insulation layer.

3. The solid-state imaging device of one of Claims 1 and 2, wherein

the optical thickness of the insulation layer is determined

according to a wavelength which the filter unit transmits.

4. The solid-state imaging device of Claim 1, wherein

the insulation layer has therein a through hole or groove extending substantially vertical to the main surface of the insulation layer, the through hole or groove being filled with a material same as the material forming the first dielectric layer, and

the filter unit transmits a wavelength determined according to a ratio between an area of the through hole or groove, and an area of the insulation layer excluding the through hole or groove, when the insulation layer is seen two-dimensionally in plane.

5. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, wherein

a portion of the insulation layer corresponding to each of the plurality of light-receiving units has an inwardly inclined lateral surface.

6. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, wherein

the optical thickness of the insulation layer continuously changes, so that each of the plurality of light-receiving units receives a particular wavelength of light.

7. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, wherein

a thickness of a portion of the insulation layer through which light is transmitted to reach each of the plurality of light-receiving units changes in two or more levels.

8. The solid-state imaging device of Claim 1, wherein

an absorbing member is provided on a main surface of one of the λ/4 multilayer films which faces away from the insulation layer, the main surface partly reflecting the incoming light.

9. The solid-state imaging device of Claim 8, wherein

the absorbing member is a color filter containing pigments or dyes.

10. A camera including a solid-state imaging device that has a filter unit that selectively transmits incoming light,

the filter unit comprising two λ/4 multilayer films, and an insulation layer sandwiched between the λ/4 multilayer films,

each of the λ/4 multilayer films including a plurality of dielectric layers, and

an optical thickness of the insulation layer being different from λ/4.

11. A manufacturing method of a solid-state imaging device including a filter unit that selectively transmits incoming light, the filter unit being formed by conducting steps comprising:

a first formation step of forming a first λ/4 multilayer film on a semiconductor substrate, the first λ/4 multilayer film being constituted by a plurality of dielectric layers;

a second formation step of forming a first insulation layer on the first λ/4 multilayer film;

a first removal step of removing the first insulation layer except for a first region;

a third formation step of forming a second insulation layer on the first λ/4 multilayer film and the first region of the first insulation layer;

a second removal step of removing a second region of the second insulation layer, the second region being positioned on the first λ/4 multilayer film; and

a fourth formation step of forming a second λ/4 multilayer film on the second insulation layer and the first λ/4 multilayer film, the second λ/4 multilayer film being constituted by a plurality of dielectric layers.

12. A manufacturing method of a solid-state imaging device including a filter unit that selectively transmits incoming light, the filter unit being formed by conducting steps comprising:

a first formation step of forming a first λ/4 multilayer film on a semiconductor substrate, the first λ/4 multilayer film being constituted by a plurality of dielectric layers;

a second formation step of forming a first insulation layer on a first region of the first λ/4 multilayer film by using a liftoff method;

a third formation step of forming a second insulation layer

on a second region of the first λ/4 multilayer film by using the liftoff method, the second region being different from the first region; and

a fourth formation step of forming a second λ/4 multilayer film on the first insulation layer, the second insulation layer, and the first λ/4 multilayer film, the second λ/4 multilayer film being constituted by a plurality of dielectric layers.

13. A manufacturing method of a solid-state imaging device including a filter unit that selectively transmits incoming light, the filter unit being formed by conducting steps comprising:

a first formation step of forming a first λ/4 multilayer film on a semiconductor substrate, the first λ/4 multilayer film being constituted by a plurality of dielectric layers;

a second formation step of forming a first insulation layer on the first λ/4 multilayer film;

a first removal step of removing the first insulation layer except for a first region;

a third formation step of forming a second insulation layer on a second region in the first region of the first insulation layer, and on a region of the first λ/4 multilayer film where the first insulation layer is not formed, by using a liftoff method; and

a fourth formation step of forming a second λ/4 multilayer film on the first insulation layer and the second insulation layer, the second λ/4 multilayer film being constituted by a plurality of dielectric layers.

14. A manufacturing method of a solid-state imaging device including a filter unit that selectively transmits incoming light, the filter unit being formed by conducting steps comprising:

a first formation step of forming a first λ/4 multilayer film on a semiconductor substrate, the first λ/4 multilayer film being constituted by a plurality of dielectric layers;

a second formation step of forming a first insulation layer on the first λ/4 multilayer film;

a first removal step of removing the first insulation layer except for a first region;

a third formation step of forming a second insulation layer on the first λ/4 multilayer film and the first region of the first insulation layer, the second insulation layer being made of a different material from the first insulation layer;

a second removal step of removing the second insulation layer, except for a portion which is formed on a second region of the first insulation layer; and

a fourth formation step of forming a second λ/4 multilayer film on the first insulation layer, the second insulation layer, and the first λ/4 multilayer film, the second λ/4 multilayer film being constituted by a plurality of dielectric layers.

15. A manufacturing method of a solid-state imaging device including a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, and a filter unit that selectively transmits incoming light, the filter unit including two λ/4 multilayer films, and an insulation layer sandwiched between the λ/4 multilayer films, each of the λ/4

multilayer films being constituted by a plurality of dielectric layers, the manufacturing method comprising:

a formation step of forming a resist in a middle of a portion of the insulation layer corresponding to each of the plurality of light-receiving units; and

a processing step of processing the portion of the insulation layer by etching, so as to have an inclined lateral surface.

16. The manufacturing method of Claim 15, wherein

in the formation step, the resist is formed so as to have an inclined lateral surface.

17. The manufacturing method of Claim 16, wherein

in the formation step, the resist is formed so as to have an inclined lateral surface, by varying an amount of exposure to light.

18. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, wherein

a wavelength of light received by each of the plurality of light-receiving units is determined based on whether the insulation layer has a portion in correspondence with the light-receiving unit, and, if the insulation layer has the portion, a thickness and/or a material of the portion of the insulation layer.

19. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally, wherein

a portion of the filter unit corresponding to each of the plurality of light-receiving units transmits a particular wavelength of light, and

the two λ/4 multilayer films are symmetrically structured with respect to the insulation layer.

20. A solid-state imaging device including a filter unit that selectively transmits incoming light, and a light-receiving unit that receives the light transmitted by the filter unit,

the filter unit comprising a λ/4 multilayer film constituted by a plurality of dielectric layers, and

among the plurality of dielectric layers constituting the λ/4 multilayer film, a dielectric layer that is positioned most distant from the light-receiving unit being made of a low refractive index material.

21. A solid-state imaging device including a filter unit that selectively transmits incoming light,

the filter unit comprising a λ/4 multilayer film constituted by a plurality of dielectric layers, and

a protective layer being provided on one of main surfaces of the λ/4 multilayer film, or within the λ/4 multilayer film.

22. The solid-state imaging device of Claim 21, wherein

the protective layer is made of silicon nitride.

23. The solid-state imaging device of Claim 1, further including:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally; and

a light-collecting unit collecting the incoming light, wherein

a portion of the filter unit corresponding to each of the plurality of light-receiving units transmits a particular wavelength, and

a main surface of the filter unit which faces away from the plurality of light-receiving units is flat.

24. A solid-state imaging device comprising:

a plurality of light-receiving units provided in a semiconductor substrate two-dimensionally; and

a filter unit that selectively transmits incoming light, wherein

the filter unit has a $\lambda/4$ multilayer film constituted by a plurality of dielectric layers, and

a distance between (i) the plurality of light-receiving units and (ii) a high refractive index layer which is positioned closest to the plurality of light-receiving units, among two or more high refractive index layers in the $\lambda/4$ multilayer film, falls within a range of 1 nm and λ.

25. A solid-state imaging device including a plurality of unit pixels arranged two-dimensionally,

each of the plurality of unit pixels comprising:

a light-receiving unit detecting an intensity of light; and

a filter unit having a λ/4 multilayer film constituted by a plurality of dielectric layers, the filter unit transmitting one of red light, green light, and blue light, wherein

the plurality of unit pixels are arranged in Bayer array, in such a manner that every four adjacent unit pixels making a square has two unit pixels that include filter units transmitting blue light.